

US007123785B2

(12) **United States Patent**
Iffergan

(10) **Patent No.:** **US 7,123,785 B2**
(45) **Date of Patent:** **Oct. 17, 2006**

(54) **OPTIC FIBER SECURITY FENCE SYSTEM**

5,015,842 A 5/1991 Fradenburgh et al.
5,434,557 A 7/1995 Alizi

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(Continued)

FOREIGN PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 4 days.

DE 361632 12/1987

(Continued)

(21) Appl. No.: **10/965,191**

OTHER PUBLICATIONS

(22) Filed: **Oct. 15, 2004**

WWW.MATIMOP.ORG, "D-Fence Electronic Fencing & Security
Systems Ltd. Profile of R&D," www.matimop.org (Tel Aviv, Israel),
p. 2, (Nov. 21, 2003).

(65) **Prior Publication Data**

US 2006/0083458 A1 Apr. 20, 2006

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(51) **Int. Cl.**

G02B 6/26 (2006.01)

(52) **U.S. Cl.** **385/13; 385/12; 340/541;**
340/551; 356/73.1; 356/540

(57) **ABSTRACT**

(58) **Field of Classification Search** **385/12–13;**
340/541, 555; 356/73.1, 450
See application file for complete search history.

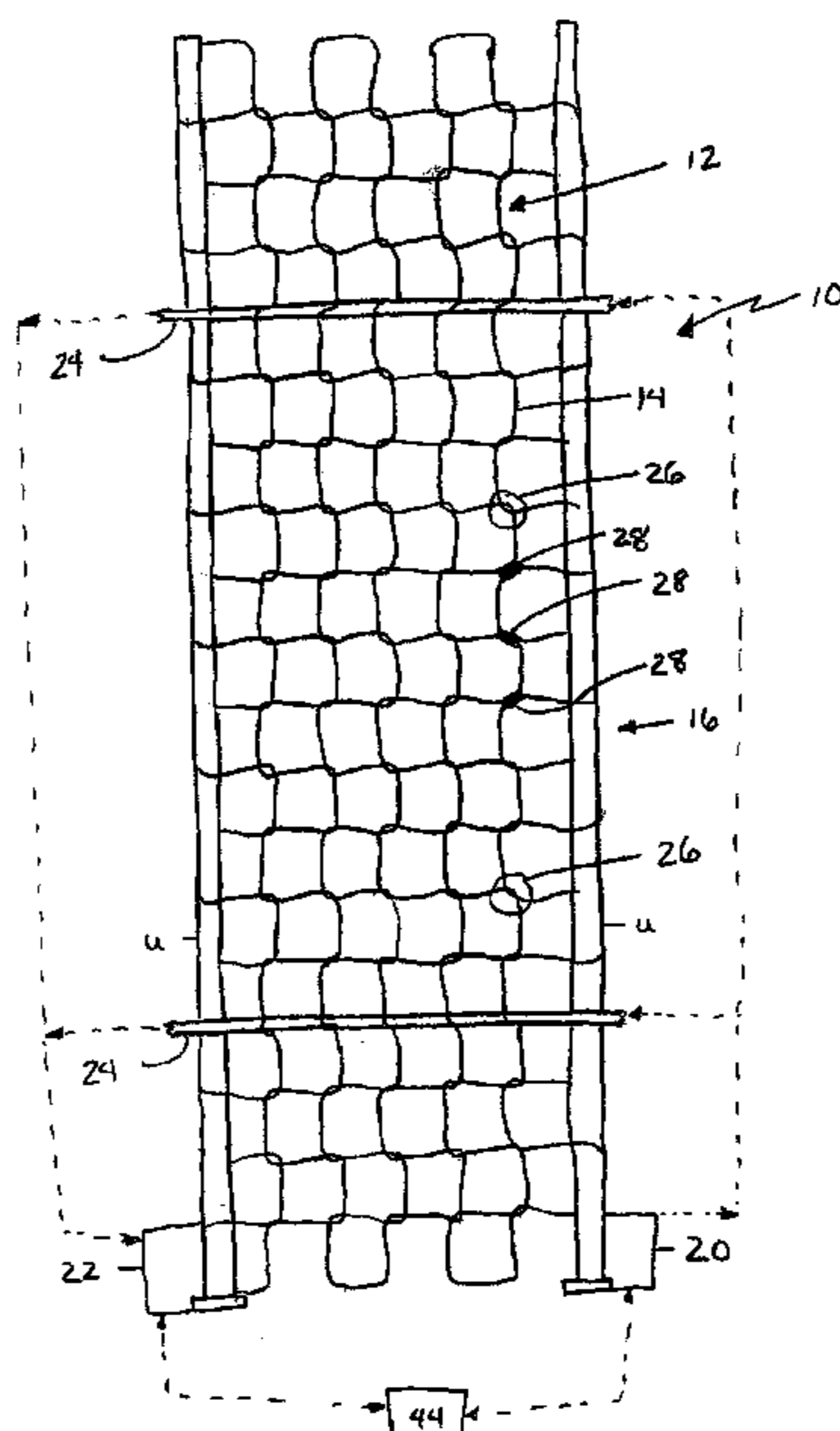
A security system is described that includes an optical fiber net woven from an optical fiber wire. A light generator introduces an incident light signal into the optical fiber wire. A light receiver receives an exigent light signal from the optical fiber wire. An optical sensor wire is connected to the optical fiber net and is displaced when a force is applied to the optical fiber net. The optical sensor wire receives a patterned incident light signal that is altered upon application of the force applied to the optical fiber net, thereby producing an altered patterned exigent light signal. The light receiver initiates an alarm either (1) if the exigent light signal from the optical fiber wire terminates, or (2) after comparing the exigent patterned light signal with the incident patterned light signal in the optical sensor wire and establishing a deviation, if the deviation exceeds a predetermined threshold.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,365,239 A	12/1982	Mongeon
4,371,869 A	2/1983	Davidson
4,399,430 A	8/1983	Kitchen
4,450,434 A	5/1984	Nielsen et al.
4,518,953 A	5/1985	Hunter et al.
4,521,767 A	6/1985	Bridge
4,558,308 A	12/1985	Ciordinik et al.
4,586,030 A	4/1986	Klostermann
4,676,485 A	6/1987	Ciordinik et al.
4,680,573 A	7/1987	Ciordinik et al.
4,777,476 A	10/1988	Dank
4,829,286 A	5/1989	Zvi
4,916,433 A	4/1990	ver Loren van Themaat

19 Claims, 7 Drawing Sheets



US 7,123,785 B2

Page 2

U.S. PATENT DOCUMENTS

5,530,430 A 6/1996 Pavlov
5,592,149 A * 1/1997 Alizi 340/550
6,400,268 B1 6/2002 Lindskog
6,583,721 B1 6/2003 Dank et al.
6,967,584 B1 * 11/2005 Maki 340/657
6,980,108 B1 * 12/2005 Gebbia et al. 340/555
2002/0053977 A1 5/2002 Perry
2003/0052254 A1 3/2003 Kudo et al.
2003/0058105 A1 3/2003 Wuestefeld et al.
2003/0141975 A1 7/2003 Hama et al.

2005/0107968 A1* 5/2005 Chun 702/69
2005/0254767 A1* 11/2005 Chun 385/136

FOREIGN PATENT DOCUMENTS

EP 0599267 6/1994
GB 2038060 A 7/1980
GB 2062321 A 5/1981
JP 3053400 3/1991

* cited by examiner

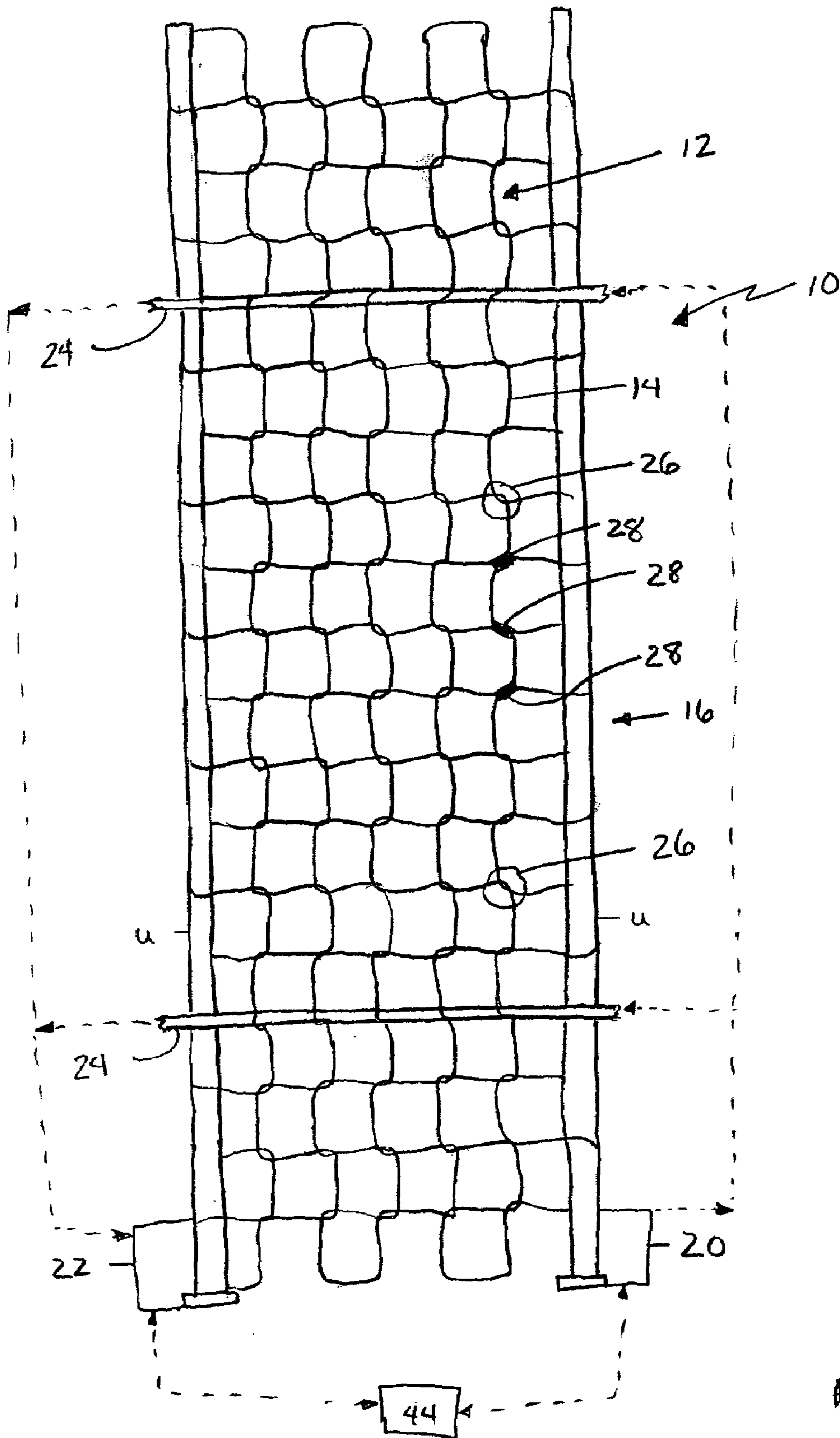


Fig. 1

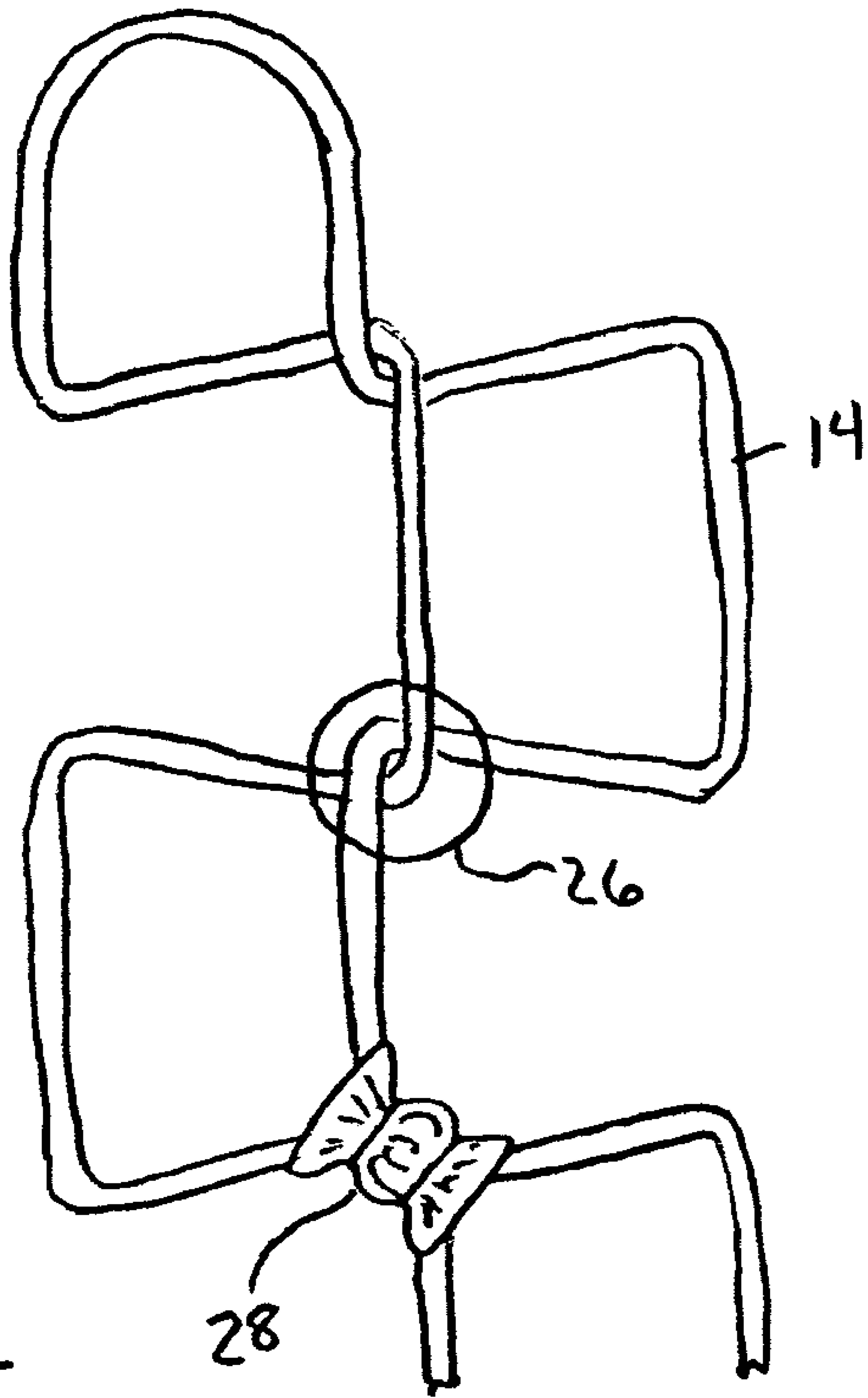


Fig. 2

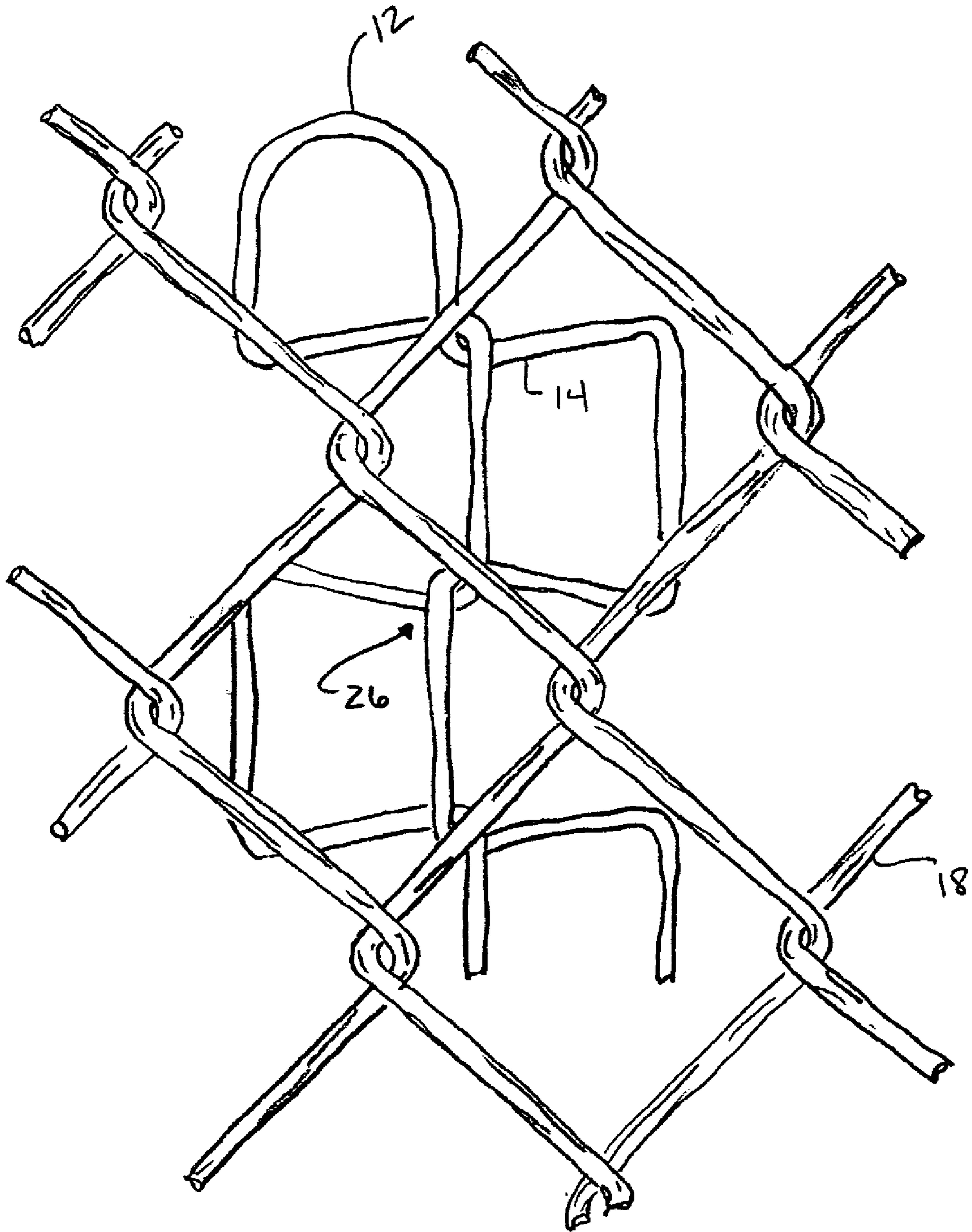


Fig. 3

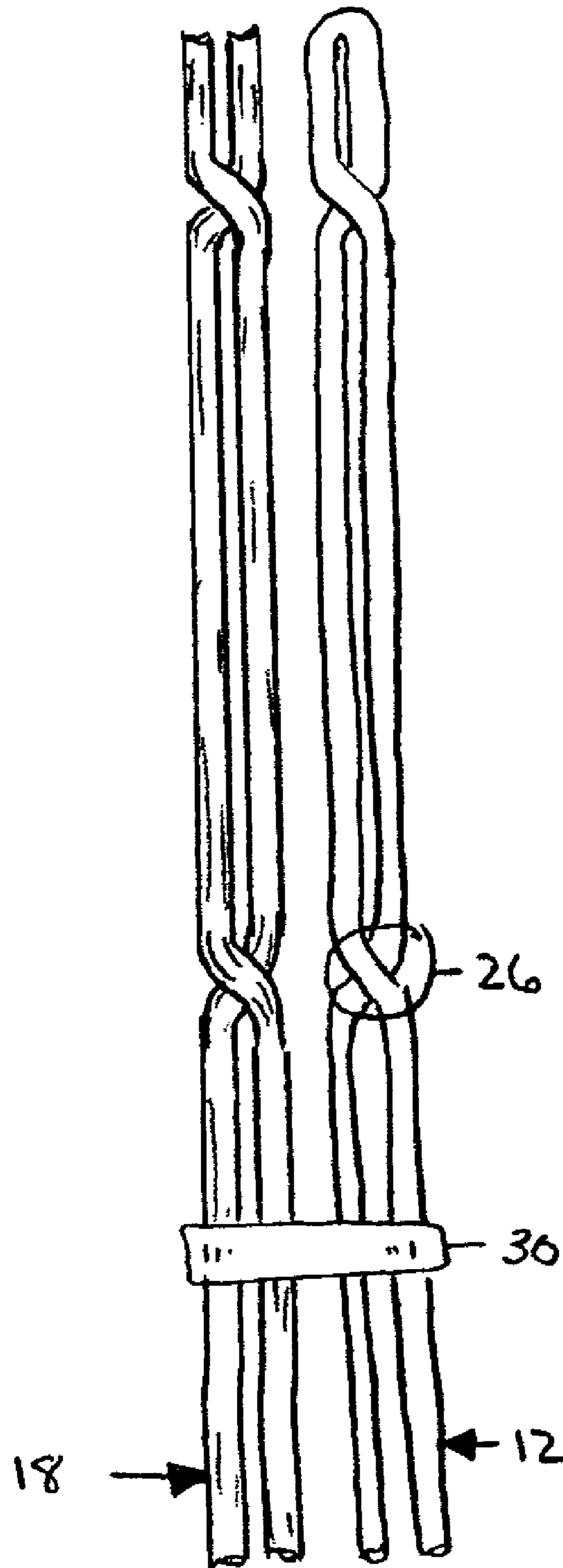


Fig. 4

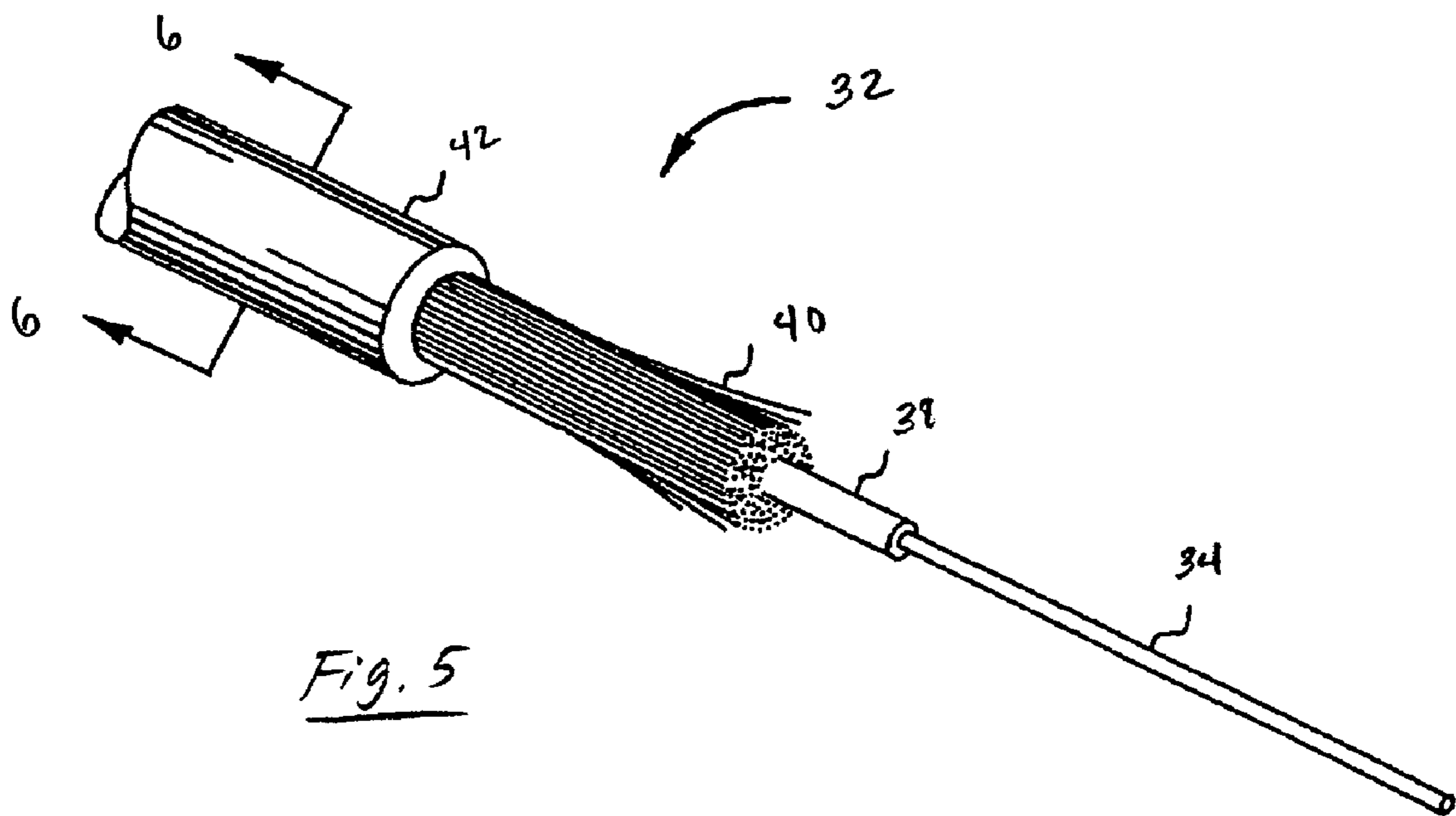


Fig. 5

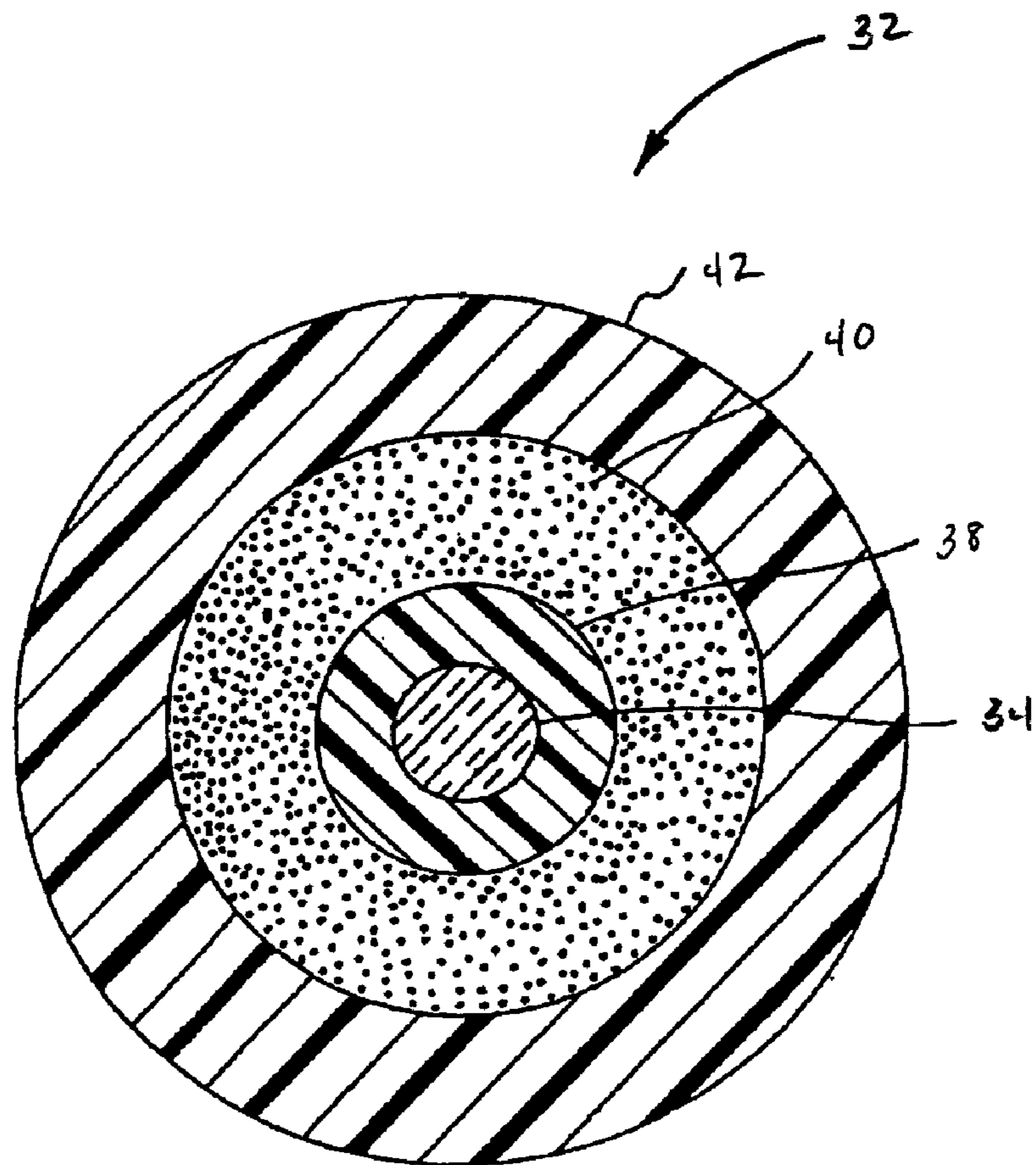
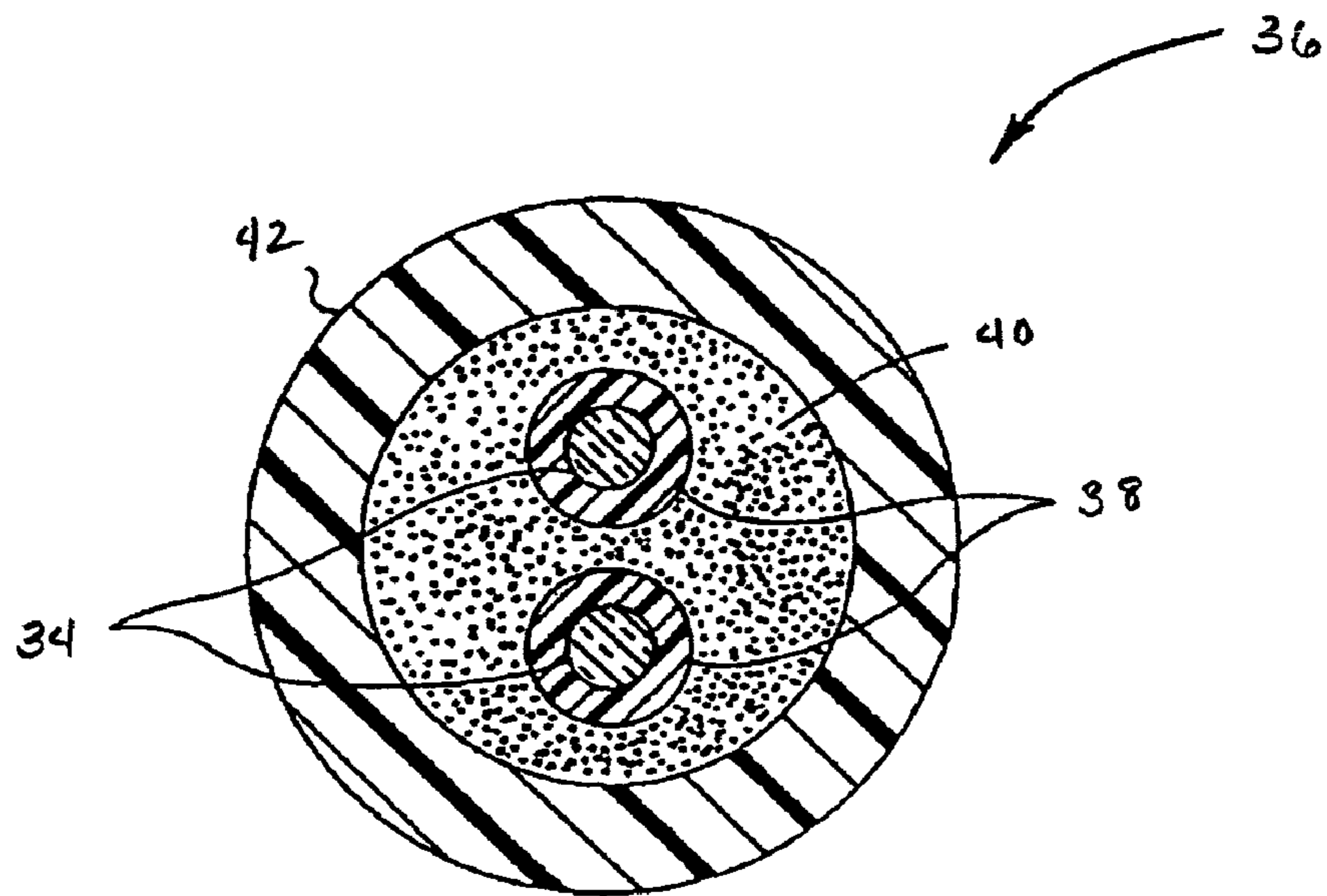
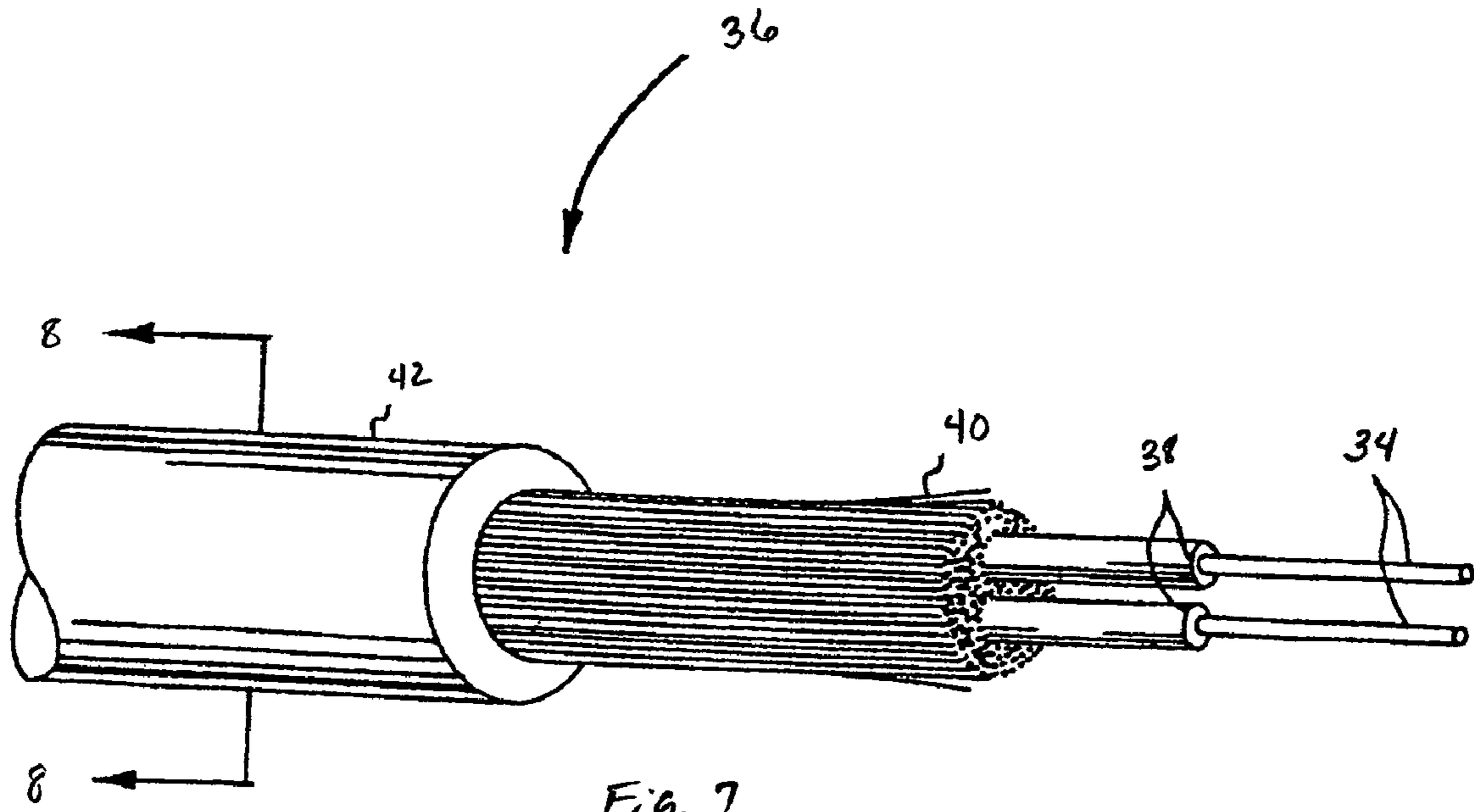


Fig. 6



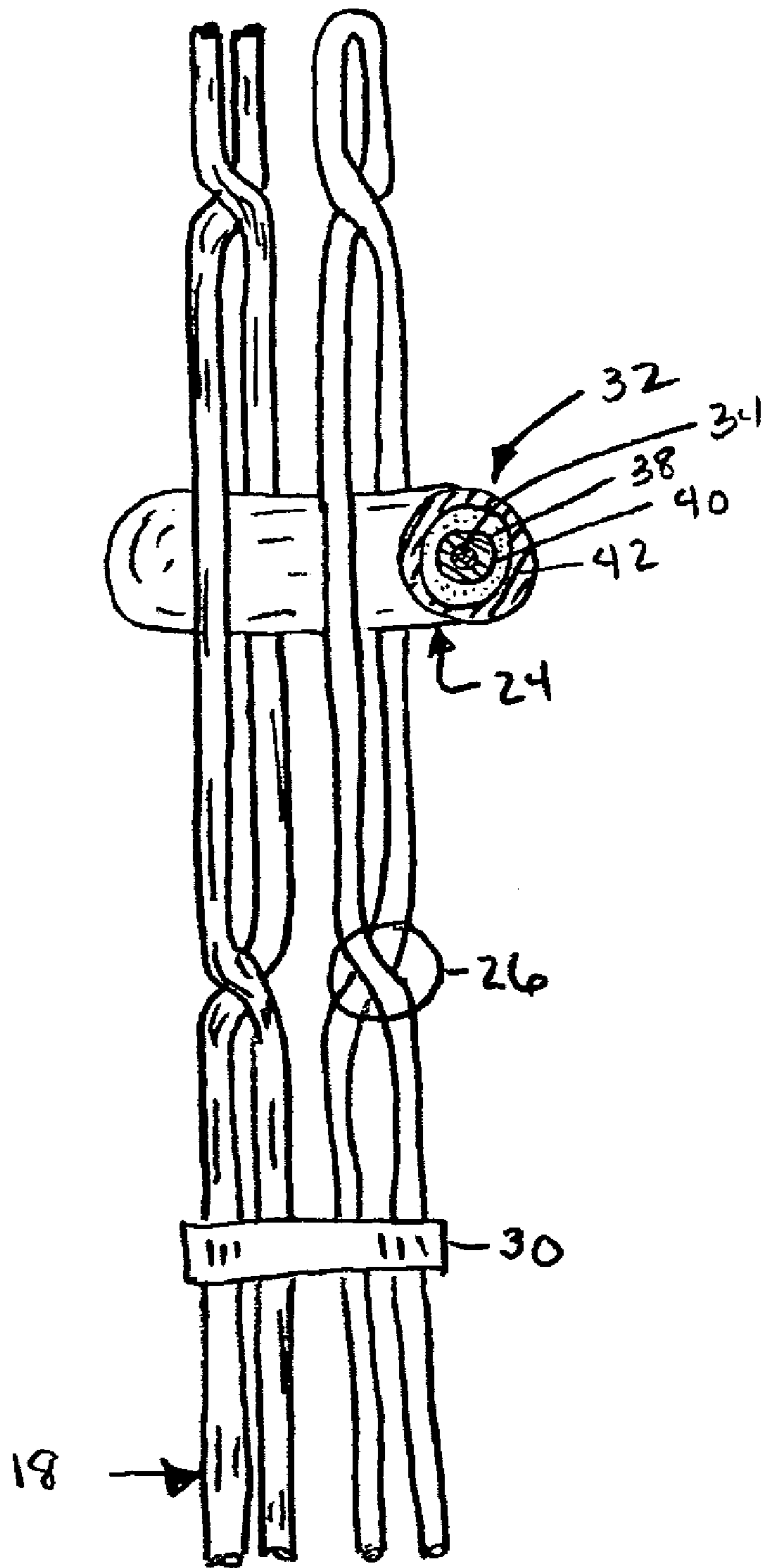


Fig. 9

OPTIC FIBER SECURITY FENCE SYSTEM

FIELD OF THE INVENTION

Very broadly, the present invention concerns the construction of a physical security barrier, such as a fence, that incorporates optic fibers into its construction. More specifically, the present invention relies on optic fiber sensitivity to detect a security breach or an attempted security breach of the physical security barrier.

BACKGROUND OF THE INVENTION

There are numerous examples of physical security fences known in the prior art. In addition, the prior art is replete with examples of physical security fences that incorporate optic fibers thereinto, at least in part, to detect breaches of the physical fence by sounding an alarm when optical fibers are severed. Several examples are discussed below.

U.S. Pat. No. 4,365,239 describes an intrusion warning system for protecting a wall or a fence, in particular a chain link fence, against intrusion (via cutting) or by climbing over same. The system combines a shielded cable **2** with a chain link fence **1**. The fence **1** is intended to extend around the perimeter of an area to be protected. The length of the shielded cable **2** may be as long as 1,000 feet (304.8 m) in the described example. The shielded cable **2** is an electrical coaxial cable with an inner conductor surrounded by an outer, shielded conductor with a layer of insulating dielectric material therebetween. In operation, a signal is sent through the coaxial cable. An attempt to break through the fence disrupts the electrical signal, triggering an alarm.

U.S. Pat. No. 4,399,430 describes an intruder detection security system including a security fence **2** made from a plurality of elongated members **4**, **6**, **8**, **10**, **12**, **14**. The elongated members are optical fibers surrounded by or coated with polyvinyl chloride ("PVC"). FIG. 9 of the '430 patent illustrates the cross-section of one of the elongated members, showing the optical fiber **1** loosely housed within a PVC tube **5** reinforced with Kevlar® strength members **3**. (Kevlar® is a trademark of the Dupont Company referring to a para-aramid fiber manufactured by that company. According to the information provided by the DuPont Company through its website, <http://www.dupont.com/kevlar/whatiskevlar.html>, Kevlar® fibers consist of long molecular chains produced from poly-paraphenylene terephthalamide.) The elongated members **4**, **6**, **8**, **10**, **12**, **14** form a mesh between two upright posts **16**, **18**. In one embodiment, at each joining point **20** of the elongated members **8**, **10**, **12**, **14**, the elongated members **8**, **10**, **12**, **14** are joined together by a steel ferrule **36**. The optical fibers **4**, **6**, **8**, **10**, **12**, **14** are connected between an output control box **22** and an input control box **24**. If the amplitude of the signals received by the output control box **22** fall outside a predetermined range, an output signal is transmitted to operate an alarm **34**.

U.S. Pat. No. 4,371,869 describes a fence or wall incorporating a fiber-optic wave guide. The security system described in the '869 patent includes a composite strip **1** of bendable material, which is referred to as a carrier strip **2**. The carrier strip **2** may be made of steel, for example. A single fiber-optic filament **3** extends within a groove running along the face of the carrier strip **2**. The carrier strip **2** preferably is coated with a corrosion-resistant layer in the form of a sheathing **4**, for example. A light source or laser generator **6** directs light into one end of the fiber-optic filament **3** and a detector **7** receives the light signal at the other end. The detector **7** is connected to a warning device

8. The warning device **8** is activated if a change in the intensity of light exiting the fiber-optic filament **3** falls outside of a predetermined range.

U.S. Pat. No. 4,450,434 describes an apparatus for determining a break in locations in fencing. As described, a cable **4** is strung along a fence **2** and is attached to the fence **2** via support means **6** (or is attached to the fence by being interwoven therein). The cable **4** is made of an optical fiber with an electrical transmission line running therealong. In the embodiment illustrated in FIG. **2**, the cable **4** is made of two optical fibers **8**, **10**, which are coated with metallized coatings **12**, **14**. The coated fibers are separated from one another by the insulating material **16** in which they are embedded. The cable **4** is connected to an LED or laser transmitter **30** at one end and a light receiver **32** at the other end. One end of the transmission line is connected to a pulse generator **34** and a pulse receiver **36**. The other end is open-circuited. The optical portion of the cable **4** carries the light signal such that a break in the light signal is detected by the level detector **40**, triggering operation of an alarm means **42**. The output of the level detector **40** is connected to the input of the electrical pulse generator **34**, which generates an electrical pulse that is reflected to the pulse receiver **36**. The time delay between the initiation and receipt of the electrical pulse permits the system to establish the location of the break.

U.S. Pat. No. 4,558,308 describes an intrusion warning wire-lattice that comprises a number of single fence sections **1** mounted between box-type posts **2**. Each fence section **1** includes solid wires (shown in dashed lines) and a serpentine coil **4** made of a hollow wire (shown in solid lines). The tubular wires encapsulate an electrical or optical conductor **8** that is connected to an alarm system, which is responsive to a break or deformation of the electrical or optical conductor **8**.

U.S. Pat. No. 4,829,286 describes a security fence system made up of a taut wire fence made of taut wires **10** strung in a parallel orientation between an anchoring post **12** and a sensor post **14**. An optical fiber **17** is threaded serially through a plurality of adjacent sensor posts and is coupled to a signal transceiver **18**. A taut wire connection element **34** is connected to the sensor post **14** and to two adjacent taut wires **36**. The connection element **34** rotatably connects to the sensor post **14**. An optical fiber engagement member **38** connects to the rod **30** so that is also rotates on the sensor post **14**. The taut wire connection element **34** and the optical fiber engagement member **38** are connected to one another such that, if the taut wire connection element **34** and the optical fiber engagement member **38** rotate with respect to one another over a long period of time, the optical fiber **42** is not disturbed. As a result, no alarm sounds. However, if the taut wire connection element **34** is rotated rapidly, the optical fiber engagement member **38** also rotates, displacing the optical fiber **42**, thereby triggering an alarm.

U.S. Pat. No. 5,530,430 describes a vibration responsive barbed tape security system. The security system is made up of multiple sections of fence barrier **1** that surround an area. The barrier includes a chain link fence **2** and a secondary barrier **4** in the form of a spiral barbed tape. A tube **24** is in contact with each loop of the spiral barbed tape. The tube **24** contains a vibration sensitive fiber optic cable **30** that transmits light in a predictable manner. Any movement or vibration of the tube vibrates the fiber optic cable, triggering an alarm.

UK Patent Application No. GB 2 038 060 describes an intruder alarm that gives an alarm when an intrusion has occurred into a protected area and also gives an alarm when

an attempt to breach a protected area is in progress. The intruder alarm includes a network of optical fiber light conductors forming or included in a fence. Light is fed into the ones of the light conductors such that penetration or attempted penetration of the light conductors triggers an alarm.

According to the English translation, Japanese Patent No. JP 3053400 describes a trespasser monitor method that detects whether a trespasser exists and the position of the trespasser by detecting the position of the reflection of an optical pulse from a disconnection point.

Prior art security systems that rely at least in part on optical fiber technology have not been widely accepted because of certain disadvantages inherent in those systems. In particular, many prior art systems are prone to produce an unacceptably high error rate in detecting incursions into a protected perimeter. Specifically, prior art systems typically signal alarms even though a breach of the secure perimeter has not occurred. In addition, prior art systems typically are very expensive. This is due, at least in part, to the number or type of optical generator or receivers that are needed for the systems to operate.

These difficulties with the prior art, among others, cry out for a solution that the present invention provides.

SUMMARY OF THE INVENTION

The present invention resolves the difficulties with the prior art enumerated above.

In one aspect, the present invention combines an optic fiber net and an optical sensor wire to construct a security system capable of detecting a breach therethrough.

In another aspect, the present invention provides a security system that detects an attempted breach of the secure perimeter by detecting an attempted climb over or crawl under the optic fiber net.

Another aspect of the present invention provides for the construction of an inexpensive security fence that incorporates an optical detection system to detect an intrusion or attempted intrusion into an area protected by the system.

Accordingly, it is one aspect of the present invention to provide a security system that includes an optical fiber net woven from at least one optical fiber wire. A light generator is connected at a first end of the optical fiber net to introduce an incident light signal into the optical fiber wire. A light receiver is connected at a second end of the optical fiber net to receive an exigent light signal from the optical fiber wire. An optical sensor wire is connected to the optical fiber net such that the optical sensor wire is displaced when a force is applied to the optical fiber net. The optical sensor wire is connected between the light generator and the light receiver. Moreover, the one optical sensor wire receives a patterned incident light signal that is altered upon application of the force applied to the optical fiber net, thereby producing a patterned exigent light signal. The light receiver initiates an alarm either (1) if the exigent light signal from the optical fiber wire terminates, or (2) after comparing the patterned exigent light signal with the patterned incident light signal in the optical sensor wire and establishing a deviation, if the deviation exceeds a predetermined threshold.

It is still another aspect of the present invention to provide a security system where the light generator includes two light sources, one producing an incident light signal for the optical fiber net, the other producing a patterned incident light signal for the optical sensor wire.

Another aspect of the present invention is to provide a security system where the light receiver includes two light

sensors, one receiving the exigent light signal from the optical fiber wire, the other receiving the patterned exigent light signal from the optical sensor wire.

One further aspect of the present invention provides for a security system that also includes a physical security barrier to which at least the optical fiber net is attached.

With regard to that aspect of the invention, the physical security barrier may be a chain link fence, a barbed wire fence, a weld mesh fence, a concrete wall palisade, a stone wall palisade, a hedge, or a brick wall palisade, to name but a few examples of the physical security barriers contemplated to be encompassed by the scope of the present invention.

An additional aspect of the present invention provides for a security system that includes a physical barrier in which at least the optical fiber net is embedded.

With regard to this aspect of the invention, the physical security barrier may be a chain link fence, a barbed wire fence, a weld mesh fence, a concrete wall palisade, a stone wall palisade, a hedge, or a brick wall palisade, to name but a few examples of the physical security barriers contemplated to be encompassed by the scope of the present invention.

A further aspect of the present invention provides for a security system where the light receiver includes a processor such as a computer, laptop, personal data assistant (PDA) or any type of processor available for a particular installation.

Another aspect of the present invention provides for a security system that includes a computer and a communications link. The communications link permits the computer to communicate with the light generator and/or the light receiver. The computer processes signals generated by the light receiver before initiating an alarm.

One more aspect of the present invention provides for a security system wherein the communications link comprises a wired connection.

One alternative aspect of the present invention provides for a security system where the communications link is a wireless connection.

A further aspect of the present invention provides for a security system that includes a physical security barrier. An optical fiber net is woven from an optical fiber wire disposed adjacent to the physical security barrier. A first light generator is connected at a first end of the optical fiber net to introduce an incident light signal into the optical fiber wire. A first light receiver is connected at a second end of the optical fiber net to receive an exigent light signal from the optical fiber wire. An optical sensor wire is connected to the optical fiber net such that the optical sensor wire is displaced when a force is applied to the optical fiber net. A second light generator is connected at a first end of the optical sensor wire to introduce a patterned incident light signal into the optical sensor wire. A second light receiver is connected at a second end of the optical sensor wire to receive a patterned exigent light signal from the optical sensor wire. The patterned incident light signal is altered upon application of the force applied to the optical fiber net, thereby producing a patterned exigent light signal. The light receiver initiates an alarm either (1) if the exigent light signal from the optical fiber wire terminates, or (2) after comparing the patterned exigent light signal with the patterned incident light signal in the optical sensor wire and establishing a deviation, if the deviation exceeds a predetermined threshold.

Further aspects of the invention will become apparent from the discussion that follows.

5

DESCRIPTION OF THE DRAWINGS

The drawings appended hereto are intended to assist in the discussion of the invention and are not intended to be limiting of the invention. Where appropriate, like reference numerals refer to like structures and components, in which:

FIG. 1 is a front plan view of one embodiment of the optic fiber net portion of the present invention;

FIG. 2 is an enlarged front view of a portion of the optic fiber net portion of the present invention;

FIG. 3 is a partial front plan view of one possible positioning of the optic fiber net portion adjacent to a chain link fence according to one embodiment of the present invention;

FIG. 4 is a partial side view of the positioning of the optic fiber net and the chain link fence illustrated in FIG. 3;

FIG. 5 is a partial perspective view of one embodiment of the optical sensor wire portion of the system of the present invention;

FIG. 6 is a cross-sectional view of the optical sensor wire illustrated in FIG. 5;

FIG. 7 is a partial perspective view of a second embodiment of the optical sensor wire portion of the system of the present invention;

FIG. 8 is a cross-sectional view of the optical sensor wire illustrated in FIG. 7; and

FIG. 9 is a side view of a portion of the optic fiber net, chain link fence, and optical sensor wire, illustrating one potential arrangement thereof.

DESCRIPTION OF THE EMBODIMENT(S) OF THE INVENTION

The security system 10 of the present invention is intended for use in a variety of applications. For example, the security system 10 may be used in combination with a chain link fence, a barbed wire fence, a weld mesh fence, a concrete wall palisade, a stone wall palisade, a hedge, a brick wall palisade, or any other freestanding physical barrier into which the security system 10 may be incorporated, onto which the security system 10 may be attached, or adjacent to which the security system 10 may be deployed. Alternatively, the security system 10 of the present invention may be erected around the perimeter of a secured area without being associated with a separate physical barrier. While specific embodiments of the invention will be described herein, the embodiments are meant to be illustrative only and are not meant to be limiting of the scope of the invention.

While the preferred embodiments of the present invention are directed to the combination of the security system 10 together with a man-made physical barrier, the invention is not limited solely to such embodiments. As indicated above, the security system 10 may be used in combination with a living physical barrier such as a hedge, for example. As would be appreciated by those skilled in the art, other living physical barriers may be substituted for a hedge without departing from the scope of the invention.

The security system 10 of the present invention is intended for application in a wide variety of specific installations. In particular, the security system 10 may be used to secure the perimeters of petrochemical plants, natural gas facilities, oil refineries, prisons, water districts and reservoirs, power plants, law enforcement facilities, airports, military bases, government buildings and installations, private buildings and installations, borders of localities, states, provinces, and countries, and any other sensitive perimeters.

6

The above listing of specific installations for the security system 10 is not intended to be exhaustive nor is it intended to limit the scope of the present invention. To the contrary, the wide variety of specific installations listed is intended to exemplify the enormous variety of specific installations where the security system 10 may be employed.

Concerning the deployment of the security system 10, it cannot be emphasized enough that the scope of uses contemplated is significantly expansive. Listed above are a few of the physical barriers with which the security system 10 may be used. Those skilled in the art would readily recognize that the list is not comprehensive of every possible example but is intended to suggest but a few possible variations. For example, a plaster wall could be the physical barrier in which (or on which) the security system 10 is embedded (or to which it attached). One contemplated use might be to secure a room within a house or a building where temporary security (e.g., for a period of a few days or weeks) is required.

On a related note, while the security system 10 is intended for use in permanent or semi-permanent security installations, it is contemplated that the security system 10 may be used to secure, for a limited time period, a defined perimeter. For example, in a situation where military personnel are deployed in a hostile environment, the security system 10 may be employed as a mobile perimeter. Since the security system 10 employs light-weight optic fiber technology, the security system 10 easily may be disassembled so that it may be moved and erected at a subsequent location.

As illustrated in FIG. 1, the security system 10 of the present invention includes an optic fiber net 12. A single optic fiber wire 14 is woven in a pattern such that the single optic fiber wire 14 forms the fiber optic net 12. In other words, the optic fiber net 12 contains only one, continuous optic fiber wire 14. This is not to say that the continuous optic fiber wire 14 may not be made up of several individual optic fiber wires 14 connected end to end via a suitable connection, as would be appreciated by those skilled in the art.

In addition, while the preferred embodiments of the security system 10 incorporate an optic fiber net 12 with a single optic fiber wire 14, it is contemplated that the security system 10 may include an optic fiber net 12 with multiple (i.e., two or more) optic fiber wires 14 stranded together. Such a construction offers advantages that the single optic fiber wire 14 does not. For example, the optic fiber net 12 may be made stronger when two or more optic fiber wires 14 are stranded together. Alternatively, with the stranded approach, if one optic fiber wire 14 breaks, the security system 10 may be switched (manually or automatically) to the remaining optic fiber wires 14 without the immediate need to replace or repair the damaged optic fiber wire 14. Moreover, additional optic fiber wires 14 may be relied upon to provide redundancy in the security system 10. If one of the optic fiber wires 14 breaks, the security system may automatically switch its operation to rely on one or more of the optic fiber wires 14 to determine if there is a breach of more than one optic fiber wire 14, which may increase the accuracy of the security system 10 and reduce the occurrence of false alarms. In addition, the security system 10 may be designed to cycle periodically between the multiple optic fiber wires 14 for added security. Other advantages of the stranded approach will be apparent to those skilled in the art.

Since the optic fiber net 12 contains only a single, continuous optic fiber wire 14 in the preferred embodiment, the optic fiber net 12 is constructed to form a continuous,

unbroken fabric. Alternatively, the optic fiber wire **14** may be woven into a plurality of individual panels **16** that may be connected (preferably optically) to one another to form a continuous fiber optic screen around the perimeter of the area to be protected.

In the preferred embodiment, the optic fiber net **12** comprises a plurality of individual panels **16** connected optically to one another in series. Alternatively, the security system **10** of the present invention may comprise a plurality of individual panels **16** that are operated independently of one another. In other words, the individual panels **16** need not be serially connected to one another for operation of the security system **10** of the present invention. In fact, in one preferred embodiment, individual panels **16** are not optically connected in series to one another, but are operated independently of one another. In another embodiment, the individual panels are operated in combination with one another. For example, two or more panels **16** are optically connected and each group of two or more panels **16** are operated independently of one another.

Manufacturing the optic fiber net **12** from a series of individual panels **16** offers at least one advantage over a construction where the optic fiber net **12** is a single, continuous fabric. In particular, if individual panels **16** are used, should one of the panels **16** become damaged or broken as the result of an intrusion (or a natural event), the damaged panel **16** may be easily removed so that a replacement panel **16** may be integrated into the security system **10**. Other advantages of this construction will be apparent to those skilled in the art.

For purposes of the discussion herein, the term "panel" (as used with panel **16**) should not be construed to be a panel **16** with any specific height or width dimensions. It is contemplated, for example, that the panel **16** may be eight feet (2.44 m) tall and four feet (1.22 m) wide. Alternatively, the panel may be twelve feet (3.66 m) tall and seven hundred fifty feet (228.6 m) wide. In still another embodiment, such as a marine environment, the panel **16** may be five hundred feet (153.4 m) tall and eighteen feet (5.49 m) wide. As the foregoing examples illustrate, the panel **16** need not be limited to any particular height or width. Each installation will have requirements that help to define the dimensional parameters associated with one panel **16**. Furthermore, as would be appreciated by those skilled in the art, a particular security system **10** may incorporate panels **16** that differ in size and shape from one another around the perimeter to be secured and are connected to one another in a patchwork fashion.

The optic fiber net **12** may be constructed to have any suitable dimensions adequate to be erected as a security barrier. As would be appreciated by those skilled in the art, each security installation will present different dimensional challenges. The construction of the security system **10** is intended to be adaptable to the various types and sizes of installations that may be encountered. Moreover, the construction of the security system **10** is intended to be flexible so that it may be adapted to a variety of terrains and topographies. In particular, since the optic fiber net **12** is flexible, it may be installed easily over uneven ground or terrain or around an irregularly-shaped perimeter.

It is noted that the illustration of the security system **10** of the present invention in FIG. **1** may be employed in a variety of different environments. Specifically, while it is contemplated that, in the preferred embodiment, that the security system **10** will be utilized in an above ground arrangement, the invention is not limited solely to just an above-ground use. It is contemplated that the security system **10** may be

employed wholly in a subterranean environment. Alternatively, the security system **10** of the present invention may be installed in a partially above ground and partially buried configuration, which discourages intrusions by digging under the security system **10**. Alternatively still, the security system **10** of the present invention may be employed in a marine environment (fresh or salt water), where a portion of a body of water, such as a harbor, is to be secured. In a marine environment, the fiber optic net **12** may be suspended from a series of buoys that encircle the protected perimeter. Other constructions for a marine environment will be apparent to those skilled in the art, and a buoy construction is not intended to limit this particular embodiment.

It is noted that these environments are meant to be exemplary only and are not intended to limit the applicability of the security system **10** to any particular environment. As would be appreciated by those skilled in the art, and as indicated above, the security system **10** of the present invention finds wide applicability to a large variety of environments too numerous to list here.

One advantage to the security system **10** of the present invention lies in the fact that the security system **10**, in one embodiment, relies on optic fiber technology to detect a breach in security or an attempted breach in security. As such, the security system **10** is immune to electromagnetic interference. Moreover, the security system **10** is immune to radio frequencies, electrostatic fields, and radiation, among other types of interference(s) that may be considered to diminish the security system's ability to function in its intended manner. One additional advantage of the security system **10** lies in the fact that the system **10** is transparent to radar microwaves. As such, if installed at an airport, the system **10** should not interfere with communications, avionics, or the operation of the air traffic control system.

As will be made apparent by the discussion that follows, the security system **10** of the invention is designed to be activated in response to a physical force or pressure exerted thereupon, even if momentary. However, the security system **10** is intended to withstand a long-term installation and is intended to be impervious to environmental factors and certain kinds of energies.

In one example, the security system **10** may be erected around the perimeter of an airport. Since the security system **10** relies on fiber optic technology to detect intrusions or attempted intrusions, the security system **10** cannot be affected by electromagnetic surges (such as lightning) in the vicinity thereof. Moreover, the security system **10** is "invisible" to radar, meaning that it does not generate reflective radar signals to the receivers at the airport. In some installations, this may be of benefit to air traffic controllers.

Radar invisibility may offer advantages in military or other high security installations. Other advantages will be appreciated by those skilled in the art and are, therefore, not recited here.

In the preferred embodiment of the invention, the optic fiber wire **14** comprises a single optic fiber that is clad in a suitable protective coating. The protective coating may be one or more layers of polyvinyl chloride and/or other materials, including aramid fibers such as Kevlar®, that provide adequate strength for the optic fiber wire **14**. The construction of the optic fiber wire **14** should permit the wire **14** to flex. Among other advantages, it is believed that flexibility of the optic fiber wire **14** will extend the operational lifetime of the security system **10**, since it is expected that the optic fiber wire **14** will be subjected to repetitive, minor stresses and strains, such as from wind or water currents, during its operational lifetime.

While, in the preferred embodiment, the coating should not be so rigid that the optic fiber wire **14** cannot flex when subjected to external forces, it is contemplated, in the alternative, that there may be instances where a rigid fiber optic net **12** is desired. If the fiber optic net **12** is made rigid, the fiber optic net **12** may be free-standing, which offers different advantages to consumers, as would be appreciated by those skilled in the art.

In FIGS. **1** and **2**, the fiber optic net **12** is illustrated schematically to emphasize the continuous nature of the weave of the optic fiber wire **14**. The fiber optic net **12** is suspended between two or more uprights **U**, which illustrates one possible manner in which the optic fiber net **12** may be secured around a protected perimeter.

In the preferred embodiment, as illustrated in FIGS. **1** and **2**, for example, the junctures **26** where the fiber optic wire **14** crosses itself are provided with a fastener **28**. The fastener **28** is also referred to as a "button." The buttons **28** are provided, preferably at each juncture **26**. While the exact structure and configuration of the buttons **28** are not the subject of the instant application, one function of the buttons **28** is to help cause a break of the optic fiber wire **14** if an intruder attempts to break or remove one of the buttons **28**. The buttons **28** may be ultrasonically welded to the optic fiber wire **14** at the junctions **26**. Naturally, while ultrasonic welding is one possible way to attach the buttons at the junctures **26**, ultrasonic welding is not required to practice the invention and adhesives, and other fasteners are contemplated to fall within the scope of the invention.

When the fiber optic net **12** is woven, its structure is such that the fiber optic net **12** retains its configuration, much like a sweater keeps its shape despite being woven from a continuous strand of yarn. Accordingly, the buttons **28** are not required to maintain the fiber optic net **12** in its net-like configuration. However, the buttons **28** are a preferred additional security feature because, as discussed, if an intruder tampers with a button **28**, the result will be a breakage of the fiber optic wire **14**, which will trigger an intruder alarm.

It should be noted that, in the preferred embodiment of the invention, a button **28** will be placed at each juncture **26**. This assures that if any button **28** is tampered with, the optic fiber wire **14** will break and an alarm will sound. The addition of buttons **28**, however, translates into an increased weight of the fiber optic net **12**. Increasing the number of buttons **28** also adds to the manufacturing cost of the optic fiber net **12**. Accordingly, it is contemplated that a button **28** will not be provided at each an every juncture **26**. In fact, it is contemplated that the buttons **28** may be arranged advantageously in a specific pattern to maximize effectiveness while minimizing both weight and cost. Alternatively, the buttons **28** may be arranged randomly, if desired.

While not needed to maintain the optic fiber wire **14** in a net-like configuration for the fiber optic net **12**, the buttons **28** are believed to assist in maintaining the fiber optic net **12** in its preferred orientation. Therefore, while it is recognized that the buttons **28** are not needed to practice the invention, the inclusion of at least some buttons **28** is preferred.

The buttons **28** may be any suitable type as would be appreciated by those skilled in the art. For example, the buttons **28** may be made from any suitable material including plastic, metal, a composite material, etc. Alternatively, instead of using buttons **28**, a thermoplastic material may be deposited at the junctures **26** in a molten state that hardens upon cooling. To this end, the optic fiber wire **14** may be coated with a thermoplastic resin during the weaving process so that the coating of the optic fiber wire **14** fastens the

optic fiber wire **14** to itself at the junctures **26**. Alternatively still, the junctures **26** could be provided with a suitable adhesive in the place of the buttons **28**. The wide variety of fasteners **28** that may be employed are too numerous to list, as would be appreciated by those skilled in the art, and the scope of the present invention is not intended to be limited to the specific embodiments (i.e., the buttons **28**) discussed above.

It is also noted that the specific weave pattern of the optic fiber net **12**, which is illustrated in FIGS. **1** and **2**, is merely a preferred pattern of weaving the optic fiber wire **14** into the optic fiber net **12**. Other patterns also may be employed and are too numerous to list herein. The other weave patterns, which would be appreciated by those skilled in the art, are also contemplated to fall within the scope of the invention.

As should be appreciated from the discussion that follows and by those skilled in the art, the optic fiber net **12** may be erected in any number of configurations. In the preferred embodiment, the optic fiber net **12** is disposed adjacent a chain link fence **18** and is connected thereto via one or more fasteners (or clips) **30**. The height of the optic fiber net **12** need not be the same height as that of the chain link fence **18**. It is contemplated, for example, that the fiber optic net **12** may extend a distance above the top of the chain link fence **18** in certain installations.

Alternatively, although not preferred, the fiber optic net **12** may be manufactured with the chain link fence **18** such that the fiber optic net **12** is interwoven into the chain link fence **18**. It is also contemplated that the chain link fence **18** may be manufactured from a hollow wire such that the optic fiber wire **14** may be threaded therein. If so constructed, the chain link fence **18** would present an outward appearance of a standard chain link fence **18** but would, in fact, incorporate features and aspects of the present invention.

As illustrated in FIG. **1**, the optic fiber wire **14** is connected at one end to a light generator **20**. The light generator **20** may be a laser or a Class **1** laser diode with an output wavelength of either 850 nm or 1300 nm, among others. The light also may include wavelengths of visible light or of any other portion (or portions) of the electromagnetic spectrum. In one embodiment, the light falls within the infrared portion of the electromagnetic spectrum. The other end of the optic fiber wire **14** is connected to a light receiver **22**. The light receiver **22** may be any type of receiver including a PIN Diode, for example.

In the preferred embodiment of the security system **10** of the present invention, the light generators **20** and light receivers **22** are positioned adjacent to the optic fiber net **12**. Since this means that the light generators **20** and light receivers **22** will be exposed to the environment, each unit is preferably constructed to withstand wind, rain, snow, heat, and cold, among other environmental conditions. The light generators **20** and light receivers **22** are, in turn connected to a monitoring station **44**, which is usually positioned at a location remotely from the individual light generators **20** and receivers **22**. The connection to the monitoring station **44** may be via a wired connection or a wireless connection, as would be appreciated by those skilled in the art. If the connection is wireless, in one embodiment, the transmission of signals may be via any suitable transmission wavelength of electromagnetic radiation including, but not limited to radio waves, microwaves, and infrared light. While not enumerated, other transmission method and means also may be employed without departing from the scope of the present invention.

In one embodiment of the security system **10** of the present invention, the signals processed may be light signals.

11

In another embodiment, the light signals may be converted to electrical signals for processing. For example, being a computing device, the monitoring station 44 is contemplated to operate via electrical signals. When the monitoring station 44 communicates to one or more of the light generators 20 and light receivers 22 via a wired connection, it is contemplated that the wired connection will be optical. Accordingly, the electrical signals processed by the monitoring station 44 must be converted to light signals for transmission to the locations of the light generators 20 and light receivers 22. To accomplish this, it is contemplated that the electrical signals will be converted to light signals via a RS-232 (or EIT-232) connection. When the optical signal is received by one or more of the control boxes located at various positions throughout the security system, the light signals are converted back to electrical signals via a RS-232 (or EIT-232) connection. In other words, conversion between light and electrical signals may occur at one or more locations within the security system 10 of the present invention, as would be appreciated by those skilled in the art.

It is also contemplated that the microprocessor with be provided with a RS-232 (or EIT-232) port so that the microprocessor may be programmed via an external microprocessor, such as a laptop computer, personal data assistant, etc. The same port also provides access to the microprocessor for diagnostic purposes and maintenance purposes, as would be appreciated by those skilled in the art.

The monitoring station 44 preferably includes a microcomputer (not shown) that sends and receives the various signals from the light generators 20 and the light receivers 22. The microcomputer may include a graphical user interface (GUI), for example, that permits monitoring of the operation of the security system 10. The microcomputer may permit calibration of the security system 10 and permit input to adjust the sensitivity of the system 10, among other features.

It is noted that the term "microcomputer" is intended to be given a broad interpretation. To avoid any misunderstandings, any of the following may be the type of microcomputer employed: (1) a personal computer, (2) a laptop computer, (3) a mainframe computer, (4) a personal data assistant (or "PDA"), etc. The microcomputer may have a program loaded with a memory (such as a Random Access Memory ("RAM")) to trigger an alarm. Alternatively, the program may be hardwired into the microcomputer in some other contemplated variations.

In yet another contemplated embodiment, it is conceivable that the monitoring station 44 may be at a location that is quite remote from the security system 10 that it monitors. For example, the monitoring station 44 may be located in one state (or local principality) while the security system 10 is located in another state (or local principality). In this embodiment, the monitoring system 44 may be connected to the security system via the Internet.

In still another embodiment, it is contemplated that a monitoring station 44 may be connected to and may monitor the operating parameter of several security systems 10 simultaneously. For example, several security systems 10 could be installed in disparate subunits of a business. All of the security systems 10, however, may feed detection information to a single monitoring station 44. When the monitoring station 44 detects a security breach or an attempted security breach, an alarm can be triggered so that security personnel may be dispatched to the appropriate location. One advantage of a centralized monitoring station 44 is a reduction in the cost of monitoring several security systems 10 simultaneously.

12

The security system 10 operates to generate an alarm upon the occurrence of several different events. First, the security system 10 is designed to detect a break in the optic fiber net 12, as discussed below. Second, the security system 10 is designed to detect an attempted breach of the secure perimeter even if the optic fiber net 12 is not broken. This may include an attempt to climb over the physical security barrier, for example, also as discussed in greater detail below.

Light emitted by the light generator 20 is conducted through the optic fiber wire 14 and is received by the light receiver 22. When the security system 10 operates, the light generator 20 is activated so that a light signal is inputted into the optic fiber wire 14. Should a person cut through the optic fiber net 12, the light signal emitted by the light generator 20 will be interrupted. The light receiver 22 will detect the absence of a light signal and will output an alarm signal that triggers, among other types of alarm indications, an audible alarm.

The security system 10 also includes at least one optical sensor wire 24 that is connected to or interwoven with the optic fiber net 12 and/or the chain link fence 18, at least in the preferred embodiment. Alternatively, the optical sensor wire 24 may be affixed to the optic fiber net 12 and need not be interwoven therewith. For the security system 10, it is contemplated that the optical sensor wire(s) 24 will be connected to the optical fiber net 12 in one fashion or another. The reason for this is that, upon application of a force to the optical fiber net 12, such as would occur if a person attempted to climb over the optical fiber net 12, the force will be transferred to the optical sensor wires 24. Alternatively, where the security system 10 is applied to a chain link fence 18, the optical sensor wires 24 may be attached to the chain link fence 18 and not be connected to the optical fiber net 12. With this construction, if an intruder attempts to climb over the fence 18, the intruder's activity will have a detectable effect on the optical sensor wires 24, as in the previous example.

As shown in FIG. 1, in one embodiment, one optical sensor wire 24 is disposed about $\frac{1}{3}$ of the distance from the top of the fiber optic net 12 and another is disposed about $\frac{1}{3}$ of the distance from the bottom of the fiber optic net 12. The arrangement is contemplated for a tall physical barrier, for example, a chain link fence 18 that is twelve feet tall (3.66 m). For a shorter chain link fence 18, only one optical sensor wire 24 may need to be employed. The optical sensor wire 24 for a shorter chain link fence 18, for example an eight foot fence (2.44 m), may be woven into the fiber optic net 12 and chain link fence 18 at an intermediate position between the top and bottom.

In still other contemplated embodiments, the optic fiber net 12 may extend a distance of four feet (1.22 m) or more above the height of the chain link fence 18. For example, the chain link fence 18 may be eight feet tall (2.44 m) and the optic fiber net 12 may be twelve feet tall (3.66 m). If so, the optic sensor wires 24 preferably are positioned $\frac{1}{3}$ of the distance (i.e., 4 ft. or 1.22 m) below the top of the optic fiber net 12 and $\frac{1}{3}$ of the distance (i.e., 4 ft. or 1.22 m) above the bottom of the optic fiber net 12. In yet another contemplated embodiment, one optic fiber net 12 and another at the bottom of the optic fiber net 12. In still another embodiment, a single optical sensor wire 24 may extend near the bottom of the optic fiber net 12, extend vertically along one of the uprights U, for example, and then transition to a horizontal path adjacent to the top of the optic fiber net 12. The optical sensor wire also may be attached to the optic fiber net 12 in a serpentine pattern. The exact arrangement of the optical

sensor wire **24** is expected to vary depending upon the particular needs of the security installation and the sensitivity required for the particular installation.

In one contemplated embodiment of the security system **10**, the optical sensor wire **24** extends along the bottom of the optic fiber net **12**, transitions vertically along one of the uprights **U**, and extends along the top of the optic fiber net **12**. In this configuration, the optic fiber net **12** is stretched between the portion of the optical sensor wire **24** at the bottom of the optic fiber net **12** and the portion of the optical sensor wire **24** at the top of the optic fiber net **12**. While a single optical sensor wire **24** may extend along both the bottom and top of the optic fiber net **12**, other configurations are also contemplated to fall within the scope of the invention. For example, one optical sensor wire **24** may extend along the bottom of the optic fiber net **12**. A second, independent optical sensor wire **24** may extend along the top of the optic fiber net. Naturally, as would be appreciated by those skilled in the art, still further variations may be employed. These variations are also intended to be encompassed by the invention.

In one embodiment, the optical sensor wire **24** is interwoven into the fiber optic net **12** and the chain link fence **18** to detect an attempted intrusion over or through the optic fiber net **12**. The optical sensor wire **24** is also designed to operate so that it may detect an attempt to cut through the chain link fence **18** to which the optic fiber net **12** is attached, as will be discussed in greater detail below.

The optical sensor wire **24** preferably is encased in a rigid (or at least semi-rigid) conduit (not shown). The conduit, in one contemplated embodiment, is made of a plastic material, but other materials also may be used. For example, the conduit could be made of a metal such as aluminum, steel, copper, or the like. Also, the conduit could be made from a composite material such as one incorporating carbon fibers.

The optical sensor wire **24** (or plurality of optical sensor wires **24**) are connected between the light generator **20** and the light receiver **22**, as indicated by the dotted lines in FIG. **1**. Alternatively, the optical sensor wire **24** may be connected between a light generator **20** and receiver **22** separate from those illustrated in FIG. **1**. Regardless of the particular arrangement employed, the light generator **20** inputs a light signal at one end of the optical sensor wire **24**. The light receiver processes the signal exigent from the optical sensor wire **24** at the other end.

In the preferred embodiment, the light signal that passes through the optical sensor wire **24** is encoded with a specific pattern (or patterns) that are altered when the optical sensor wire **24** is disturbed during operation of the security system **10**. The light patterns that pass through the optical sensor wire are referred to as "speckle patterns." The exact details of the speckle patterns are not critical to the operation of the present invention. In fact, each security installation may rely on a different speckle pattern so that intruders familiar with the general construction and operation of the security system **10** of the present invention may not learn the details of one speckle pattern and employ that knowledge to breach others of the same security systems **10** at different locations. In addition, it is contemplated that the speckle pattern for a particular installation may be altered periodically so that the same speckle pattern is not employed all of the time. For example, it is expected that the speckle pattern may be rotated through a series of different patterns on a regular basis, such as hourly, daily, weekly, or whatever period is desired. This is expected to decrease the possibility that an intruder may be able to reverse engineer the speckle pattern

and introduce a false speckle pattern designed to "trick" the security system **10** and, thereby, gain access to the secure perimeter.

In the preferred embodiment of the security system **10** of the present invention, any vibration (or disturbances, however brief) of the optical sensor wire **24** disturbs the speckle pattern carried thereby. This alters the speckle pattern, which alteration is detected by the light receiver **22** (or microprocessor). If the pattern deviates more than a predetermined amount from the initial signal, an alarm is triggered.

It is contemplated that the sensitivity of the security system **10** will be selected for each installation depending on the required level of security. Preferably, the sensitivity of the security system **10** will be such that the speckle pattern through the optical sensor wire **24** will trigger an alarm only upon the detection of a disturbance of a predetermined magnitude. The sensitivity of the security system **10** may be adjustable via interaction through the GUI (or other input/output device) associated with the microcomputer or computer, as the case may be.

The security system **10** is also designed to detect an attempt to cut through the chain link fence **18** while leaving the optic fiber net **12** in tact. When an intruder cuts through a chain link fence **18**, the cutting tool will create a momentary vibration (called a "ping") as the cutting tool severs one of the links in the fence **18**. The "ping" is a vibrational disturbance that travels through the chain link fence **18** to the optical sensor wire **24**. The nature of the ping is such that it will momentarily disturb the speckle pattern traveling through the optical sensor wire **24**, which will cause the light receiver **22** to initiate an alarm.

Another type of intrusion that the security system **10** detects is a break in the optic fiber net **12**, as discussed above. If the optic fiber net **12** is broken, the light signal traveling through the optic fiber wire **14** is terminated, causing the light receiver **22** to initiate an alarm.

As may be appreciated from the foregoing discussion, the sensitivity of the optical sensor wire(s) **24** is such that they may also detect other types of intrusions and attempted intrusions including, but not limited to, an attempt to lift, crawl under or pass through the optical fiber net **12** and/or the chain link fence **18** (in one embodiment).

While these types of intrusion are discussed in connection with the deployment of the security system **10** with a chain link fence **18**, the same types of disturbances are detectable for other types of physical security barriers, including walls, etc., as listed above.

Since the optical sensor wire **24** permits the detection of intrusions and attempted intrusions, the physical spacing between the optical sensor wires **24** affects the sensitivity of the security system **10**. The closer the optical sensor wire **24** is to an attempted intrusion, the greater is the ability of the optical sensor wire **24** to detect the intrusion. Accordingly, it is contemplated that the security system **10** of the present invention may incorporate more than two optical sensor wires **24** interwoven into the fiber optic net **12** and/or the chain link fence **18**, as may be required by the particular demands for the specific installation. More than two optical sensor wires **24** also may be required in a marine installation, for example, where the height of the optic fiber net **12** is likely to exceed twelve feet (3.66 m).

It is also contemplated in one embodiment that the optical sensor wire **24** may be employed only with the fiber optic net **12**. In other words, the optical sensor wire **24** may be used even if the fiber optic net **12** is not attached to a chain link fence **18** or other physical security barrier. The operation of the optical sensor wire **24** is the same regardless of whether

or not a physical security barrier, such as a chain link fence **18**, is associated with the security system **10**.

The optical sensor **24** wire may have one of two preferred embodiments. In the first embodiment, the optical sensor wire **24** is a single optic fiber cable **32** with a single optic fiber **34** disposed therein. In the second embodiment, the optical sensor wire **24** is a double optic fiber cable **36** with two optic fibers **34** disposed therein. The first embodiment of the optical sensor wire **24** is illustrated in FIGS. **5** and **6**. The second embodiment is illustrated in FIGS. **7** and **8**. As would be appreciated by those skilled in the art, more than two optic fibers **34** may be disposed in the optical sensor wire **24**, if desired. Accordingly, the security system **10** of the present invention is not limited solely to these two embodiments.

As illustrated in FIGS. **5** and **6**, the fiber optic cable **32** has a multi-mode optic fiber **34** at its core. The optic fiber **34** is a 62.5/125 multi-mode fiber with a silica/germania core with a diameter of $62.5 \pm 3 \mu\text{m}$. Alternatively, the optic fiber **34** may be a 50/125 multi-mode fiber with a silica/germania core with a diameter of approximately $50 \mu\text{m}$. The core is silicon cladded to a diameter of $125 \pm 2 \mu\text{m}$. A tight buffer **38** is provided around the optic fiber **34** to a diameter of $900 \pm 100 \mu\text{m}$. The tight buffer **38** may be Teraflex PVC **126**, or equivalent. An aramid yarn **40** is stranded around the tight buffer **38**. The aramid yarn **40** may be Kevlar® or Twaron®. Eight yarns of 1580 dtx are used. A green polyurethane jacket **42** is extruded over the aramid yarn **40** with a minimum thickness of 1 mm. The green polyurethane jacket **42** may be Goodrich 58202, Goodrich 58304, or a Wilson green masterbatch with UV protection 140GN20. The final diameter of the optic fiber cable **32** is $4.0 \pm 0.01 \text{ mm}$. The optic fiber cable **32** has a minimum bending radius of 2.5 mm, which permits knotting of the cable **32** without breakage of the optic fiber **34**.

As illustrated in FIGS. **7** and **8**, the fiber optic cable **36** has two multi-mode optic fibers **34** at its core. The optic fibers **34** are 62.5/125 multi-mode fibers with a silica/germania core with a diameter of $62.5 \pm 3 \mu\text{m}$. Alternatively, the optic fiber **34** may be a 50/125 multi-mode fiber with a silica/germania core with a diameter of approximately $50 \mu\text{m}$. The core of each fiber **34** is silicon cladded to a diameter of $125 \pm 2 \mu\text{m}$. A tight buffer **38** is provided around each optic fiber **34** to a diameter of $900 \pm 100 \mu\text{m}$. The tight buffer **38** may be Teraflex PVC **126**, or equivalent. An aramid yarn **40** is stranded around the tight buffer **38**. The aramid yarn **40** may be Kevlar® or Twaron®. Eight or more yarns of 1580 dtx are used. A green polyurethane jacket **42** is extruded over the aramid yarn **40** with a minimum thickness of 1 mm. The green polyurethane jacket **42** may be Goodrich 58202, Goodrich 58304, or a Wilson green masterbatch with UV protection 140GN20.

It is also contemplated that the security system **10** of the present invention may rely on optic fibers with a larger or smaller diameter. For example, the security system **10** may incorporate optic fibers **34** with a $50 \mu\text{m}$ diameter, as would be appreciated by those skilled in the art.

Additionally, it is contemplated that the fiber optic cables **32**, **36** may incorporate "swellable" aramid yarn fibers therein. Kevlar® fibers are one such example, although many alternatives may be employed without departing from the scope of the invention. Incorporating swellable fibers into the fiber optic cables **32**, **36** offers further advantages. Swellable fibers absorb water and swell as a result of the absorption of water. If swellable fibers are incorporated in the fiber optic cables **32**, **36**, and if the polyurethane jacket **42** becomes damaged, the fibers will absorb water that enters the fiber optic cable **32**, **36** and prevent the water from

migrating within the fiber optic cable **32**, **36**. Moreover, swellable optic fibers also help to prevent water from reaching the optic fibers **34** because the fibers prevent (or at least inhibit) the radial migration of water within the fiber optic cable **32**, **36**.

In one contemplated embodiment of the invention, it is contemplated that the fiber optic cables **32**, **36** will have different outside diameters depending upon the particular environment in which the fiber optic cables **32**, **36** are employed. For example, in a ground-based environment, it is preferred that the fiber optic cables **32**, **36** have an outside diameter of about 4.0 mm. In a marine environment, which is expected to a more unfriendly environment, it is preferred that the outside diameter of the fiber optic cables **32**, **36** be about 4.4 mm. The larger diameter provides a more robust construction that is expected to withstand the more turbulent environmental conditions under water. Moreover, it is preferred that the two different cables be visually coded so that they may be distinguishable easily from one another. For example, the ground-based fiber optic cable **32**, **36** may be tinted or colored green while the marine-based fiber optic cable **32**, **36** may be tinted or colored blue. These colors also may assist in camouflaging the optical fiber nets **12** in the environments where they are positioned.

One advantage that the security system **10** offers over the prior art lies in the fact that the system relies on at least two sensor schemes to detect an intrusion or attempted intrusion into the secure perimeter. In particular, the addition of the optical sensor wire(s) **24** to the optical fiber net **12** permits the security system **10** to detect disturbances of the optical fiber net **12** separate and apart from actual breaks in the optical fiber net **12**. Moreover, this construction offers other advantages over the prior art. In particular, a fewer number of light generators **20** and light receivers **22** are required as compared with the prior art. One reason for this is the addition of the optical sensor wire(s) **24** to the optical fiber net **12**.

With respect to the design of prior art security fences, it has traditionally been known to rely solely on the optic fiber net **12** for detection of security breaches. This poses a difficulty because each 100 meters (about 300 ft.) of optic fiber net **12** incorporates about 3000 m (about 10,000 ft.) of optic fiber wire **14**. Inevitably, there are transmissive losses of light as it travels through any optic fiber wire **14**. To accommodate this, traditional security fence manufacturers position a light generators and light receivers at intervals of about every 300 feet (or about every 91.44 m) from one another along the length of the fence.

The cost of each microprocessor can be substantial. Therefore, in a security installation where the security fence is several miles long (1 mile=1609.34 m), the cost rapidly escalates. Another difficulty with the traditional system is that the signal microprocessor (the light receiver) merely detects a loss of the light signal.

Another prior art fence that is known also relies on the optic fiber net to provide information about a breach in the net. In this other example, one signal microprocessor is positioned regularly along the length of the fence. The signal microprocessor relies on OTDR (optical time domain reflectometry) technology to detect a breach in the security fence. A significant drawback to this design is that the signal microprocessor can be quite expensive.

The security system **10** of the present invention provides the ability to detect both an intrusion and an attempted intrusion. In addition, the cost of the system is considerably less than prior art systems. Furthermore, the false alarm rate

of the security system 10 of the present invention is considerably less than systems in the prior art.

As will be appreciated by those skilled in the art, the security system 10 of the present invention is a considerable improvement over security systems known in the art because the detection features of the security system 10 have been segregated into two components. First, the security system 10 permits detection of a breach in the optic fiber net 12 because a break in the optic fiber wire 14 will result in a loss of the light signal to the light receiver 22 at the end of the panel 16 or series of panels 16. Second, an attempted intrusion through the optical fiber net 12 will be detected the optical sensor wire 24. If the fence 18 is disturbed to an extent that the speckle pattern passing through the optical sensor wire 24 is disrupted or altered to an extent that exceeds a predetermined threshold, the light receiver 22 will trigger an alarm.

One aspect of the security system 10 of the present invention, therefore, lies in the separation of detection of a breach (e.g., a breach in the optic fiber net 12) and detection of a disturbance of the fence 18 by the optical sensor wire 24. Since the optical sensor wire 24 extends in an essentially linear fashion along the fence 18 (at a particular height or particular heights of the fence 18), the light passing through the optical sensor wire 24 travels a lesser comparative distance than the light passing through the optic fiber net 12. Accordingly, the light receiver 22 may be positioned at a considerably greater distance from the light generator 20 than in security barriers known in the art. Simply, the fact that the optical sensor wire 24 does not extend through a convoluted path (as compared to the optical fiber wire 14) presents a combination that greatly simplifies the construction of the security system 10.

In operation, one light signal is inputted by the light generator into one end of the optic fiber wire 14 that forms the optic fiber net 12. A separate light signal, preferably coded with a speckle pattern, is generated by the light generator 12 and passes through the optical sensor wire 24. Of course, as would be appreciated by those skilled in the art, the same light signal may be introduced into both the optic fiber wire 14 and the optical sensor wire 24 without departing from the scope of the present invention.

So constructed, the security system of the present invention requires a pair of light generators 20 and light receivers 22 at regular intervals. Since the security system 10 of the present invention relies on variance of the speckle pattern carried by the optical sensor wire 24 to detect a breach or attempted breach, the microprocessor is considerably less complex than the OTDR example. As a result, the microprocessor costs a mere fraction of the cost of the OTDR-type system.

Another advantage inherent in the construction of the security system 10 of the present invention lies in the fact that the sensitivity of the system may be easily adjusted by altering the magnitude of the predetermined deviation of the speckle pattern transmitted through the optical sensor wire 24 that will trip an alarm. In other words, the sensitivity of the security system may be increased by decreasing the amount of deviation of the speckle pattern needed to trigger an alarm. Conversely, the sensitivity of the security system 10 can be decreased by increasing the amount of speckle pattern deviation needed to trigger an alarm.

Accordingly, in a preferred embodiment of the invention, the sensitivity of the optical sensor wire 24 to disturbances is adjustable by the system operator. Adjustability offers considerable advantages. For example, if a particular installation finds that there are ten false alarms per day (due to

animals touching the fence 18, for example), the operators may change the alarm threshold to reduce the number of false alarms (which renders the number of times security personnel are required to investigate a breach or an attempted breach in security).

While it is not expected that the speckle pattern threshold (the threshold required to trigger an alarm) will be adjusted frequently, it is contemplated that the threshold may need to be adjusted at least seasonally. For example, in winter, the environment when the security system 10 is installed may offer a more windy set of circumstances, which might require a proportional decrease in the sensitivity of the microprocessor. Similarly, if it rains, the sensitivity of the security system 10 may need to be altered to accommodate for the disturbances created when raindrops strike the security system 10.

In each of the embodiments discussed, it is assumed that the light passing through the optical fiber wire 14 remains constant since, to detect a breach, merely requires the absence of the light signal at the light receiver. It is contemplated that the security system 10 may be designed so that the intensity of the light passing through the optical fiber wire 14 may be altered. In addition, it is contemplated that a speckle pattern may be introduced into the optical fiber wire 14 to permit detection of an attempted breach by detecting an deviation in the speckle pattern.

Since the speckle pattern may be introduced into the optical fiber wire 14, one embodiment of the invention contemplates that the microprocessor will control the light input. In another embodiment, this result may be accomplished manually. Here, it is contemplated that the light generators 20 will be provided with at least two pairs of output ports. One pair of output ports is for the optical sensor wire and the other pair is for the optical fiber wire 14. One of each of the pair of outputs generates a speckleless light pattern, while the other generates a speckled light pattern. One end of the optical sensor wire 24 plugs into one of the output ports (preferably the output providing light with the speckle pattern). One end of the optical fiber wire plugs into one of the other pair of output ports (preferably the output port without the speckle pattern). Providing these ports provides greater system flexibility, as would be appreciated by those skilled in the art.

While the security system 10 of the present invention has been described in connection with specific embodiments thereof, the present invention is not intended to be limited solely to the embodiments described. As will be appreciated by those skilled in the art, elements of the invention may be altered from the specifics discussed above without departing from the scope and spirit of the invention. Moreover, it is intended that all equivalents that will be appreciated by those skilled in the art also fall within the scope of the present invention as discussed above and as recited by the claims appended hereto.

What is claimed is:

1. A security system, comprising:

- an optical fiber net woven from at least one optical fiber wire;
- a light generator connected at a first end of the optical fiber net to introduce an incident light signal into the optical fiber wire;
- a light receiver connected at a second end of the optical fiber net to receive an exigent light signal from the optical fiber wire; and
- at least one optical sensor wire connected to the optical fiber net such that the at least one optical sensor wire is displaced when a force is applied to the optical fiber

19

net, the at least one optical sensor wire being connected between the light generator and the light receiver, the at least one optical sensor wire receiving a patterned incident light signal that is altered upon application of the force applied to the optical fiber net, thereby producing a patterned exigent light signal, wherein the light receiver comprises two light sensors, one receiving the exigent light signal from the optical fiber wire, the other receiving the patterned exigent light signal from the optical sensor wire, and wherein the light receiver initiates an alarm either (1) if the exigent light signal from the optical fiber wire terminates, or (2) after comparing the patterned exigent light signal with the patterned incident light signal in the at least one optical sensor wire and establishing a deviation, if the deviation exceeds a predetermined threshold.

2. The security system of claim 1, wherein the light generator comprises two light sources, one producing an incident light signal for the optical fiber net, the other producing a patterned incident light signal for the optical sensor wire.

3. The security system of claim 1, further comprising: a physical security barrier to which at least the optical fiber net is attached.

4. The security system of claim 3, wherein the physical security barrier comprises at least one selected from a group comprising: a chain link fence, a barbed wire fence, a weld mesh fence, a concrete wall palisade, a stone wall palisade, a hedge, or a brick wall palisade.

5. The security system of claim 1, further comprising: a physical barrier in which at least the optical fiber net is embedded.

6. The security system of claim 5, wherein the physical security barrier comprises at least one selected from a group comprising: a chain link fence, a barbed wire fence, a weld mesh fence, a concrete wall palisade, a stone wall palisade, a hedge, or a brick wall palisade.

7. The security system of claim 1, wherein the light receiver comprises a computer.

8. The security system of claim 1, further comprising: a computer; and a communications link, permitting the computer to communicate at least with the light generator and the light receiver, wherein the computer processes signals generated by the light receiver before initiating an alarm.

9. The security system of claim 8, wherein the communications link comprises a wired connection.

10. The security system of claim 8, wherein the communications link comprises a wireless connection.

11. A security system, comprising: a physical security barrier; an optical fiber net woven from at least one optical fiber wire disposed adjacent to the physical security barrier; a first light generator connected at a first end of the optical fiber net to introduce an incident light signal into the optical fiber wire;

20

a first light receiver connected at a second end of the optical fiber net to receive an exigent light signal from the optical fiber wire;

at least one optical sensor wire connected to the optical fiber net such that the at least one optical sensor wire is displaced when a force is applied to the optical fiber net;

a second light generator connected at a first end of the optical sensor wire to introduce a patterned incident light signal into the optical sensor wire;

a second light receiver connected at a second end of the optical sensor wire to receive a patterned exigent light signal from the optical sensor wire,

wherein the patterned incident light signal is altered upon application of the force applied to the optical fiber net, thereby producing a patterned exigent light signal, wherein the light receiver initiates an alarm either (1) if the exigent light signal from the optical fiber wire terminates, or (2) after comparing the patterned exigent light signal with the patterned incident light signal in the at least one optical sensor wire and establishing a deviation, if the deviation exceeds a predetermined threshold.

12. The security system of claim 11, further comprising: a physical security barrier to which at least the optical fiber net is attached.

13. The security system of claim 12, wherein the physical security barrier comprises at least one selected from a group comprising: a chain link fence, a barbed wire fence, a weld mesh fence, a concrete wall palisade, a stone wall palisade, or a brick wall palisade.

14. The security system of claim 11, further comprising: a physical barrier in which at least the optical fiber net is embedded.

15. The security system of claim 14, wherein the physical security barrier comprises at least one selected from a group comprising: a chain link fence, a barbed wire fence, a weld mesh fence, a concrete wall palisade, a stone wall palisade, or a brick wall palisade.

16. The security system of claim 11, wherein the light receiver comprises a computer.

17. The security system of claim 11, further comprising: a computer; and a communications link, permitting the computer to communicate at least with the light generator and the light receiver, wherein the computer processes signals generated by the light receiver before initiating an alarm.

18. The security system of claim 17, wherein the communications link comprises a wired connection.

19. The security system of claim 17, wherein the communications link comprises a wireless connection.

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